

Calculation of forest potential productivity for Tianshan forest region

LUO Ming-can, QIN Jia-li

(Southwest Forestry College, Kunming 650224, P.R. China)

LI Hu

(Xinjiang Agricultural University, Urumqi 830052, P.R. China)

Abstract: Forest Potential Productivity (FPP) of 8 counties in Tianshan was calculated, and the potential timber output of these counties was analyzed with Miami Model and Thornthwaite Memorial Model. Research results showed that annual average output of present stand in Tianshan Forest Region was $3.7 \text{ m}^3/(\text{hm}^2 \cdot \text{a})$, which reached only 49% of average FPP.

Key words: Forest potential productivity; Miami Model; Thornthwaite Memorial Model; Output

CLC number: S711

Document code: B

Article ID: 1007-662X(2001)01-0073-02

Introduction¹

Forest Potential Productivity (FPP) is organic dry matter produced in the unit area per year in specific climate condition. FPP also equals to net first production of forest, namely, general biomass production through forest photosynthesis minus the quantity consumed by forest respiration and the dead leaves and branch. In some regions, generally speaking, these factors, such as biological feature of forest, oxygen and carbon dioxide content in the air and soil fertilizer force, etc., always keep relatively constant value. However the climate condition always varies with different seasons, so forest productivity mainly depends on the sun light, heat and water. According to all above, FPP means the photosynthetic capacity affected by comprehensive climate factors, which is the possible productivity that forest transfers sunlight into chemical energy, namely, theory productivity. The objective of this study is to analyze FPP of Tianshan Forest Region, in order to provide referring data for local forestry plan and produce.

Study areas

Study area is situated in Yili Prefecture of the western part of Xinjiang Vigor Autonomous Region ($80^{\circ} 9' 42'' - 84^{\circ} 56' 50'' \text{ E}$, $42^{\circ} 14' 16'' - 44^{\circ} 55' 30'' \text{ N}$) in China. Climate type belongs to continental climate of semi-arid moist of Temperate Zone. Annual temperature is averaged 8.5°C . The extreme temperature values are -36.6°C and 37.9°C . Total annual precipitation around study area is about 500

mm.

Vegetation type belongs to desert region of temperate zone. Dominant species is *Picea schrenkiana*, which distributes from 1 700-2 500 m over sea level in the form of pure forest. Forest volume and forest area of the species accounts for 99% and 95% of forest of Yili Prefecture, respectively. There are 8 counties in the prefecture, namely, Nilleke, Xinyuan, Gonliu, Tekesi, Huochen, Yinin, Cabucaer and Zhaosu.

Methods

Miami model

According to the relation between plant output and annual average temperature, annual average precipitation in worldwide, in 1972, H. Lieth (Lieth 1972) got following mathematics model:

$$T_t = 3000 / (1 + e^{1.315 - 0.119t}) \quad (1)$$

$$T_N = 3000 (1 - e^{-0.000664N}) \quad (2)$$

Where:

t --annual average temperature ($^{\circ}\text{C}$);

N --annual average precipitation (mm);

T_t -- plant dry-matter output based on temperature ($\text{g} \cdot \text{cm}^{-2} \cdot \text{a}^{-1}$);

T_N -- precipitation (mm). Lieth called two formulations above as Miami Model.

Thornthwaite Memorial Model

In fact, besides temperature and precipitation, plant output is still affected by other climate factors, so reliability of calculating result with Miami model is only 66%-75% (Yuan *et al.* 1991). Therefore, in 1974, on basis of Thornthwaite study, Lieth put forward to Thornthwaite Memorial Model. He used the factor-evapotranspiration to calculate plant output because the factor depends on a series of climate factors, such as sun radiation, temperature, precipitation,

Biography: LUO Ming-can (1961-), male, associate professor in Southwest Forestry College, Kunming 650224, P.R. China.

Received date: 2000-11-26

Responsible editor: Zhu Hong

air pressure, wind, etc.. So evapotranspiration is a comprehensive indicator of the state of water and heat of some region. The Thornthwaite Memorial Model is as follows:

$$T_V = 3000[1 - e^{-0.0009695(V-20)}] \quad (3)$$

Where:

T_V --plant output on basis of real evapotranspiration ($\text{g} \cdot \text{cm}^{-2} \cdot \text{a}^{-1}$);

3000--the highest dry-matter output (g) of natural plant per year and per unit area calculated by Lieth;
 V --annual average evapotranspiration (mm), can be calculated by following formulation:

$$V = 1.05N/[1 + (1.05N/L)^2]^{-0.5} \quad (4)$$

Where:

N --annual average precipitation (mm);

L --the highest evapotranspiration of annual average; which is the function of temperature (t), e.g.:

$$L = 300 + 25t + 0.05t^2 \quad (5)$$

only when $N > 0.316L$, the formulation above is applicable. If $N < 0.316L$, then $N = V$.

This study applies respectively Miami Model and Thornthwaite Memorial Model to calculate FPP of 8 counties of Tianshan Forest Region in Yili Prefecture.

Climate factors

In this study, average climate factors were observed by local meteorological station, in 10 years and in 8 counties of Tianshan Forest Region (Table 1).

Table 1. Average value of main meteorological factors (1989-1999)

Site	Sunshine time/h	Accumulating temperature ($>10^\circ\text{C}$)/ $^\circ\text{C}$	Annual precipitation/mm	Average air temperature/ $^\circ\text{C}$
Nileke	2 795.8	2 369.2	353.4	5.7
Xinyuan	2 693.5	2 952.2	479.7	8.1
Gonliu	2 731.9	3 055.4	256.6	7.4
Tekesi	2 732.2	2 292.2	382.8	5.3
Huochen	2 869.5	3 534.0	218.9	9.1
Yinin	2 802.4	3 310.6	257.5	9.2
Cabucaer	2 810.7	3 389.1	205.9	7.9
Zaosu	2 699.0	1 316.9	512.0	2.9

Results

We take the data of Table 1 into Miami Model and Thornthwaite Memorial Model, and calculate FPP distribution (Table 2).

According to calculating result, output with the formulation of Thornthwaite Memorial Model reflects comprehensively affection of all climate factors, and

the Thornthwaite Model is more suitable for calculation of FPP than Miami Model.

FPP of 8 Counties in Tianshan Forest Region ranges from $5.7 \text{ m}^3/(\text{hm}^2 \cdot \text{a})$ to $10 \text{ m}^3/(\text{hm}^2 \cdot \text{a})$, and average FPP is $7.6 \text{ m}^3/(\text{hm}^2 \cdot \text{a})$. However, annual average output of present stand in Tianshan Forest Region is $3.7 \text{ m}^3/(\text{hm}^2 \cdot \text{a})$, and is only 49% of average FPP. So, efficient measures must be taken to enhance forest productivity.

Table 2. Forest Potential Productivity (FPP) of forest region in Tianshan

Site	$T_i/\text{kg} \cdot \text{hm}^{-2} \cdot \text{a}^{-1}$	$T_N/\text{kg} \cdot \text{hm}^{-2} \cdot \text{a}^{-1}$	$T_V/\text{kg} \cdot \text{hm}^{-2} \cdot \text{a}^{-1}$	Potential timber output / $\text{m}^3 \cdot \text{hm}^{-2} \cdot \text{a}^{-1}$	Present stand output / $\text{m}^3 \cdot \text{hm}^{-2} \cdot \text{a}^{-1}$
Nileke	10 380.0	6 274.5	6 484.5	7.8	3.6
Xinyuan	12 393.0	8 184.0	8 338.5	10.0	3.4
Gonliu	11 793.0	4 699.5	5 664.0	6.8	4.0
Tekesi	10 059.0	6 733.5	7 018.5	8.4	4.1
Huochen	13 267.5	4 059.0	5 064.0	6.1	3.5
Yinin	13 354.5	4 714.5	5 791.5	6.9	3.0
Cabucaer	12 220.5	3 834.0	4 767.0	5.7	4.7
Zaosu	8 247.0	8 646.0	7 273.5	8.7	3.6
Average	11 464.3	5 893.1	6 300.2	7.6	3.7

References

- Lieth, H. 1972. Modeling the primary productivity of the world natural resources [M]. UNESCO, Paris, p68-81.
 Yuan Jiazuo and Zhang Hanxiong. 1991. Option model of forest vegetation construction in yellow-land Plateau [M]. Beijing: Science Press, p20-45.